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The initial experience of 4.5/6.5 Fr ureteroscopic laser lithotripsy under topical intraurethral anesthesia supplemented by preoperative and intraoperative medications

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Abstract

Purpose To assess the safety and effectiveness of the 4.5/6.5 Fr ureteroscopic laser lithotripsy (URSL) under topical intraurethral anesthesia (TIUA) compared to spinal anesthesia (SA).

Methods A retrospective study was conducted on 47 (TIUA: SA = 23:24) patients receiving 4.5/6.5 Fr URSL from July 2022 to September 2022. For the TIUA group, atropine, pethidine, and phloroglucinol were used apart from lidocaine. In the SA group, patients received lidocaine and bupivacaine. We compare the two groups including stone-free rate (SFR), procedure time, anesthesia time, overall operative time, hospital stay, anesthesia failure, intraoperative pain, need for additional analgesia, cost, and complications.

Results The conversion rate in the TIUA group was 4.35% (1/23). SFR was 100% in both groups. Surgical waiting time and anesthesia time were longer in the SA group ($P < 0.001$). There were no statistical differences in operational time and intraoperative pain. Patients developed grade 0–1 ureteral injuries. Post-surgical time out of bed was noticeably faster in the TIUA group ($P < 0.001$). The post-operative complication rate including vomiting and back pain was lower in the TIUA group ($P = 0.005$).

Conclusion TIUA had an equal surgical success rate and controlled patients' intraoperative pain as SA. It was superior in terms of TIUA's patient admission, waiting time for surgery, anesthesia time, post-operative time out of bed, low complications, and costs, especially for females.

Keywords Ureteral calculi · Local anesthesia · Thin ureteroscopy · Holmium laser lithotripsy

Introduction

Ureteral stones are a common urologic disease in developed and developing countries, which has caused a tremendous economic burden on families and societies [1]. With the advancement of smaller caliber ureteroscopes, use of access sheaths, digital endoscopes, improved optics, and lasers of ureteroscopy, the management of ureteral stones has been undergoing great progression [2]. Nowadays, ureteroscopic

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lithotripsy surgery is proposed as the preferred treatment method for ureteral calculi, which causes less surgical injury than percutaneous nephrolithotomy (PCNL) and provides higher stone clearance than extracorporeal shockwave lithotripsy (ESWL) [3].

An economical and efficient surgery program is critical for a disease [4] with a high incidence and reoccurrence rate. Apart from the miniaturization of devices [5], anesthesia is also an indispensable part of a successful ureteroscopy procedure. Since the twentieth century, there have been reports [6] showing that the success rate of ureteroscopic lithotripsy under TIUA was comparable to that under general or SA. However, concerning the patient having difficulty tolerating the procedure under TIUA, the known literature addresses this phenomenon by combining intravenous sedation and analgesia anesthesia with TIUA. Scarce data mention the possibility of reducing intraoperative anesthetic method changes by adding preoperative medications.

In this study, we compared the safety and effectiveness of 4.5/6.5 Fr ureteroscopic lithotripsy under mucosal surface anesthesia supplementary preoperative medications with SA.

Materials and methods

Patients and methods

Patients management

We retrospectively analyzed the clinical data of 47 patients receiving 4.5/6.5 Fr URSL under SA (24/47) or TIUA (23/47) at our institution from July 2022 and September 2022.

Patients with ureteral calculi were diagnosed by kidney-ureter-bladder (KUB) X-ray examinations, Ultrasound (US) or computed tomography (CT), which contributes to assess the stone size and location. Patients present with imaging ureteral stones that do not pass spontaneously > 6 mm or require early intervention due to recurrent colic or urinary tract obstruction.

Regarding the definition of the ureteral portion, the ureteropelvic junction to the upper border of the sacroiliac joint was defined as the upper ureter, the mid ureter was the part from the ureter anterior to the sacroiliac joint, and the lower ureter was the part from the distal edge of the sacroiliac joint to the ureterovesical junction.

All patients underwent routine preoperatively physical examinations including blood routine, biochemical parameters and electrocardiogram (ECG). All patients prophylactically used sensitive antibiotics 30 min prior to surgery. The formula of stone surface area was length × width × 3.14 × 0.25 [7]. The ureteral injury was assessed depending on the grading system [8], divided into grade 0–4. Surgery waiting times was defined as from admitting to hospital to operation. The hospital stay was defined as the day of surgery and the day of discharging. The cost of surgery is mainly for surgical instruments and consumables, and the cost of anesthesia includes anesthetic drugs and anesthesiologist's operating fee. Lithotripsy status was evaluated intraoperatively by direct ureteroscopy and postoperatively by KUB. RMB is the currency of China. Patients were asked to score intraoperative pain using a visual analog score (VAS).

All operational procedures were performed under endoscope by experienced urologists. Patients were asked to grade the pain scale preoperatively and intraoperatively. We informed the patients about the advantages and disadvantages of local anesthesia and conventional anesthesia methods. The final decision was made by patients, and they were required to submit a written informed consent for surgery. Ethic approval was deemed to be unnecessary for the retrospective design of this study according to the local ethics committee.

Anesthesia management

In TIUA group, 0.5 mg of atropine sulfate injection, 100 mg of pethidine hydrochloride intramuscular injection, and 120 mg of phloroglucinol intravenous infusion were used preoperatively to reduce the risk of ureteral injury caused by possible painful movement. After the patient was placed at the lithotomy position, a single 10 ml dose of 2% lidocaine was given and retained in the urethra 10–15 min. In SA group, we elected space between the third and forth lumbar vertebra (L3~4) in the lateral recumbent position as anesthetic puncture points. Lidocaine was used for local infiltration anesthesia in the skin, and bupivacaine was slowly injected epidurally. They were not given any preoperative medications similar to the supplementary medications in the TIUA group.

If the patient's pain level increased but was still tolerable, we would add an additional 5 ml dose of 2% lidocaine by the urologist. A staff nurse administered the use of intraoperative medications. We intraoperatively administered oxygen to the patient and measured heart rate, blood pressure, and oxygen saturation. If intraoperative pain is not tolerated, the staff nurse called the anesthesiologist to switch the anesthesia method to intravenous anesthesia (intravenous propofol injection).

Operative management

All patients were prohibited from eating and drinking 4–6 h. The ureteroscopic lithotripsy was performed under a rigid, tapered scope (4.5/6.5 Fr, Wolf, Germany). The surgeon passed 4.5/6.5 Fr URS into the bladder, completed the

bladder and ureteric orifice observation. The URS was then advanced through the ureteric orifice (guided by a standard hydrophilic soft guidewire, as needed). The stones were pulverized by the holmium laser (200 μm, Lumenis, America), and its energy was setted at 1.0 J and the frequency was 20 Hz. We used a water pump (with a power setting at 50–100 mmHg, flow setting at 0.3–0.6 L/min) with 0.9%NS continuous irrigation to maintain a clear ureteroscopic view and hypopressure in the urinary system until the operation was done. Treatment results were defined as stones broken down to 1–2 mm. The pulsed perfusion pump flushed out the majority of stone powder and the rest of the stone powder was recommended to rely on the patient's spontaneous stone expulsion.

Antibiotics were administered to patients for about 1 day. The patients were recommended to drink more water and execute early post-operative walking. All patients received a Double-J stents and were advised to take KUB to assess the placement. Patients were suggested to remove double-J stents within 4–6 weeks after surgery.

Statistics

Data analysis was performed with SPSS version 27.0 software (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed as mean (standard deviation) or median (interquartile range) when needed, and Categorical variables as frequency with percentage. Comparison between continuous variables was done using Mann–Whitney U test or Student's t test. Chi-square test or Fisher's exact test were used for categorical variables. Variables decreased postoperatively compared to preoperatively is represented by "−" and increased variables is represented by "+". The statistical significance was set by P\0.05.

Results

Clinical characteristic of the patients is presented in Table 1

The two groups were comparable in age (P = 0.107), gender (P = 0.746), stone size (P = 0.608), stone surface area (P = 0.140) and location of the stones (P = 0.147).

Operative outcome of ureteroscopic Ho: YAG laser lithotripsy in 47 patients

One patient in the TIUA group failed to tolerate the procedure. As is shown in the Table 2, the overall stone-free rate (SFR) was 100% in both groups. The surgery waiting times was longer in the SA group compared to the TIUA group (1002 ± 348 VS 597 ± 32 min, P < 0.001). The overall anesthesia time was significantly shorter in the TIUA group than in the SA group [10.00 (10.00–15.00) VS 20.00 (18.25–22.00) min, P < 0.001]. There were no statistically differences in operation time between the two groups [33.50 (25.00–47.75) VS 33.00 (25.00–50.25) min, P = 0.930]. All patients developed grade 0–1 ureteral injuries. RBC and HGB had a decrease in two groups after surgery, and there was no significant difference. The median (P25, P75) RBC in the TIUA group was − 0.13 × 1012/L (− 0.18 to − 0.09), less than − 0.14 × 1012/L (− 0.17 to − 0.07) of the SA group (P = 0.628). The median (P25, P75) HGB in the TIUA group was higher than the SA group (− 2.50 ± 0.46 VS − 2.39 ± 0.55 g/L, P = 0.382). Post-operative WBC was increased no matter which anesthesia method was used. In TIUA group, CREA was higher in TIUA group, whereas it showed a reverse result in SA group. Although the mean intraoperative pain score of the TIUA group (2.45 ± 0.60)

Table 1 Patient characteristics of TIUA and SA group

Varibles	TIUA group (n = 22)	SA group (n = 24)	P	χ^2
Age (years), mean (SD)	51.14 ± 12.06	44.54 ± 14.80	0.107	–
Gender, n (%)			0.746	0.105
Female	20 (82.60)	20 (83.33)		
Male	2 (8.70)	4 (16.67)		
Stone size, n (%)			0.608	0.2663
≤ 10 mm	15 (68.2)	18 (75.0)		
> 10 mm	7 (31.8)	6 (25.0)		
Stone surface area, mm^2, median (P25–P75)	42.00 (31.40–70.65)	27.87 (19.63–46.32)	0.140	–
Stone location, n (%)			0.147	3.830
Proximal	0	3 (12.50)		
Mid	2 (9.1)	4 (16.67)		
Distal	20 (90.9)	17 (70.83)		

TIUA topical intraurethral anesthesia, *SA* spinal anesthesia, *SD* standard deviation

Table 2 Operative outcome of ureteroscopic Ho: YAG laser lithotripsy in 46 patients

Operative outcome	TIUA	SA	P	χ^2
SFR, n (%)	100	100	–	–
Surgery waiting times, (min), mean (SD)	597.00 ± 321.00	1002.00 ± 348.00	P < 0.001	–
Anethesia time, (min), median (P25–P75)	10.00 (10.00–15.00)	20.00 (18.25–22.00)	P < 0.001	–
VAS during lithotripsy, mean (SD)	2.45 ± 0.60	2.25 ± 0.53	0.225	
Operation time, (min), median (P25–P75)	33.50 (25.00–47.75)	33.00 (25.00–50.25)	0.930	–
Post-operative time out of bed, (min), mean (SD)	1.95 ± 1.65	518.79 ± 123.68	P < 0.001	–
Hospital staying, (min) mean (SD)	2030.40 ± 849.60	3600.00 ± 1195.20	P < 0.001	–
RBC, $\times 10^{12}$/L, median (P25–P75)	− 0.13 (− 0.18 to − 0.09)	− 0.14 (− 0.17 to − 0.07)	0.628	–
WBC, $\times 10^{9}$/L, mean (SD)	0.32 ± 3.34	0.29 ± 3.12	0.974	–
CREA, umol/L, median (P25–P75)	1.50 (− 22.50–20.25)	− 6.50 (− 34.50 to 29.00)	0.783	–
HGB, g/L, mean (SD)	− 2.50 ± 0.46	− 2.39 ± 0.37	0.382	–
Post-operative complication rate, n (%)	3 (14.29)	14 (58.33)	0.005	8.02
Nausea and vomiting	0	3 (12.50)		
Dizziness	0	4 (16.67)		
Backache	3 (14.29)	7 (29.17)		
Operation expense, RMB, mean (SD)	8561.34 ± 2013.73	10,953.47 ± 27,853.81	0.002	–
Anethesia expense, RMB	38.70	780.00	P < 0.001	

TIUA topical intraurethral anesthesia, *SA* spinal anesthesia, *SD* standard deviation. *RBC* red blood cell, *WBC* white blood cell, *CREA* serum creatinine, *VAS* visual analog scale

was higher than that of the SA group (2.25 ± 0.53), the difference was not statistically significant (P = 0.225). Compared with the SA group, the postsurgical time out of bed was noticeably faster in the TIUA group (518.79 ± 123.68 VS 1.95 ± 1.65 min, P < 0.001). And, the post-operative complications rate was lower in the TIUA group (P = 0.005). The overall operating cost of the TIUA group was significantly less than that of the SA group (8561.34 ± 2013.73 VS 10,953.47 ± 27,853.81 RMB, P = 0.001). Meanwhile, the median anesthesia expenses in the TIUA group was 38.70 RMB, less than 780.00 RMB of the SA group. The hospital staying in TIUA group was shorter than SA group (P = 0.05).

Comparison of pre-operative and post-operative variables in TIUA group

In Table 3, we compared pre-operative with post-operative variables in TIUA group. RBC (P = 0.054) and HGB (P = 0.622) were not significantly different, and WBC (P = 0.614) and CREA (P = 0.814) were not statistically difference. In addition, the pain scale had little change (P = 0.109).

Comparison of pre-operative and post-operative variables in SA group

In Table 4, RBC (P = 0.398), WBC (P = 0.650), CREA (P = 0.893), HGB (P = 0.583) and VAS (P = 0.200) of pre-operative were not statistically different from post-operative variables in SA group.

Comparison of pre-operative variables in TIUA and SA group

In Table 5, we compared the preoperative characteristics of the patients between two groups, deeming it comparable.

Table 3 Comparison of pre-operative and post-operative varibles in TIUA group

Varibles	Pre	Post	P
RBC, $\times 10^{12}$/L, median (P25–P75)	4.73 (4.67–5.04)	4.64 (4.51–4.90)	0.054
WBC, $\times 10^{9}$/L, mean (SD)	8.72 ± 2.35	9.04 ± 1.83	0.614
CREA, umol/L, median (P25–P75)	83.50 (76.75–98.75)	89.50 (73.75–99.00)	0.814
HGB, g/L, mean (SD)	124.16 ± 16.63	121.67 ± 16.65	0.622
VAS, median (P25–P75)	2 (1–3)	2(1–2)	0.109

Pre pre-operative, *Post* post-operative. *RBC* red blood cell, *WBC* white blood cell, *CREA* serum creatinine, *VAS* visual analog scale

Comparison of post-operative variables in TIUA and SA group

In Table 6, post-operative variables were compared in TIUA and SA group. RBC in TIUA group was lower than the SA group (P = 0.047). And HGB in TIUA was also lower than SA (P = 0.049). WBC (P = 0.040) and VAS (P = 0.023) in two groups were statistically different.

Discussion

With the continuous maturity of ureteroscope technology and the wide application of minimally invasive techniques in clinical practice, endoscopic ureteroscopy with high lithotripsy efficiency has become the prior choice in the treatment of ureteral calculi [9]. As to the anesthesia method, the optimal treatment remains controversial. In recent years, ureteroscopic lithotripsy under local anesthesia has been being undertaken worldwide, it has not yet been applied extensively. The special phenomenon is largely due to anatomical structure and those risks brought by pain [10, 11]. The causes of the pain are mainly derived from the moment when the ureteroscope is inserted into the urethra, and excessively high pressure of the urinary system [12]. As to whether 4.5/6.5 Fr ureteroscope under local anesthesia can be successfully used in clinical, the equal lithotripsy efficiency and intraoperative pain control are crucial.

In our clinical practice, apart from 2% lidocaine (Fig. 1e), we combined atropine (Fig. 1d), pethidine hydrochloride (Fig. 1b) preoperatively, and used phloroglucinol (Fig. 1c) intraoperatively as our operational assistance medicine to ensure the muscular relaxation and nerve block.

Nociceptive stimuli are transmitted to the spinal cord via type A slow fibers and type C fast fibers and then to the brain centers. The resulting visceral pain is transferred to the somatic distribution, which corresponds to the spinal segment innervated by the sympathetic nerves of the ureter. Phloroglucinol acts on spastic smooth muscle. Nevertheless, it does not cause symptoms such as hypotension or

Table 4 Comparison of pre-operative and post-operative varibles in SA group

Varibles	Pre	Post	P
RBC, $\times 10^{12}$/L, mean (SD)	5.12 ± 0.51	5.00 ± 0.51	0.398
WBC, $\times 10^{9}$/L, mean (SD)	7.51 ± 2.30	7.80 ± 2.12	0.650
CREA, umol/L, median (P25–P75)	84.50 (69.00–129.75)	91.50 (73.00–98.75)	0.893
HGB, g/L, mean (SD)	133.49 ± 14.96	131.10 ± 14.99	0.583
VAS, mean (SD)	2.46 ± 1.18	2.08 ± 0.78	0.200

Pre pre-operative, *Post* post-operative. *RBC* red blood cell, *WBC* white blood cell, *CREA* serum creatinine, *VAS* visual analog scale

Table 5 Comparison of pre-operative varibles in TIUA and SA group

Varibles	TIUA group	SA group	P
RBC, $\times 10^{12}$/L, median (P25–P75)	4.73 (4.67–5.04)	5.25 (4.69–5.56)	0.063
WBC, $\times 10^{9}$/L, mean (SD)	8.72 ± 2.35	7.51 ± 2.30	0.086
CREA, umol/L, median (P25–P75)	83.50 (76.75–98.75)	84.50 (69.00–129.75)	0.714
HGB, mean (SD)	124.16 ± 16.63	133.49 ± 14.96	0.051
VAS, mean (SD)	1.86 ± 0.89	2.46 ± 1.18	0.062

Pre pre-operative, *Post* post-operative. *RBC* red blood cell, *WBC* white blood cell, *CREA* serum creatinine, *VAS* visual analog scale

Table 6 Comparison of post-operative varibles in TIUA and SA group

Varibles	TIUA group	SA group	P
RBC, $\times 10^{12}$/L, median (P25–P75)	4.64 (4.51–4.90)	5.09 (4.56–5.45)	0.047
WBC, $\times 10^{9}$/L, mean (SD)	9.04 ± 1.83	7.80 ± 2.12	0.040
CREA, umol/L, median (P25–P75)	89.50 (73.75–99.00)	91.50 (73.00–98.75)	0.834
HGB, mean (SD)	121.67 ± 16.65	131.10 ± 14.99	0.049
VAS, median (P25–P75)	2.00 (1.00–2.00)	2.00 (2.00–2.75)	0.023

Pre pre-operative, *Post* post-operative. *RBC* red blood cell, *WBC* white blood cell, *CREA* serum creatinine, *VAS* visual analog scale

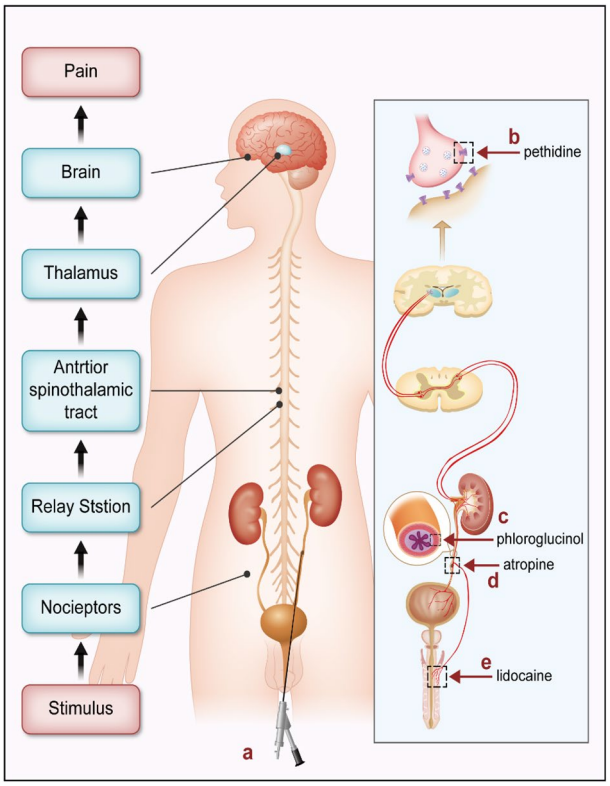

Fig. 1 Nociceptors perceive the surgical stimulus and then upload the signal to the brain through the sensory fibers to produce pain–pain ascending pathway (**a**). The key steps of the nerve block of our operation are outlined below. Pethidine hydrochloride agonizes μ and κ receptors in the central nervous system (**b**). Phloroglucinol acts on spastic smooth muscle (**c**). Atropine acts on the cholinergic M3 receptors of smooth muscle (**d**). Lidocaine acts on mucosal nerves (**e**)

arrhythmias, and has little effect on cardiovascular function [13, 14]. Atropine acts on the cholinergic M3 receptors of smooth muscle to relieve smooth muscle spasm, provide better visualization and facilitate surgery [15]. As an opioid antispasmodic analgesic, pethidine hydrochloride agonizes μ and κ receptors in the central nervous system, and causes significantly higher satisfaction scores than morphine, producing less side effect risk [16]. Thus, our ureteroscopic lithotripsy blocks both the central nerve that produces pain and the visceral nerve that supplies the ureter, achieving complete analgesia effect (Fig. 1). In our subjects, we found that the pain scale was not significantly different between two groups. All of these patients developed great intraoperative tolerance and were less uncomfortable concerning the stimulation of the miniaturization of the ureteroscope under local anesthesia. All patients completed lithotripsy surgery treatments successfully under regional anesthesia without got extra pain score.

Some literature showed good results of ureteroscopic lithotripsy under local anesthesia in recent years. Through a review of published URS articles on the use of various ureteroscopes, intracorporeal lithotripsy devices and stone locations, it was revealed that success rates ranged from 85 to 97% [17, 18]. In our experience, the overall stone-free rate in TIUA group was 100%, which was consistent with the success rate in SA group. It indicated that the method of anesthesia had little effect on the SFR.

Spinal anesthesia and general anesthesia need preoperative bowel preparation, food and water prohibition. Avoiding the routine cleansing enema means short surgical waiting time and rapid post-operative recovery of gastrointestinal tract. Moreover, the burden of cardiovascular would be reduced when the ureteroscopic lithotripsy under no general anesthesia [19]. The procedure under local anesthesia from admitting into hospital to operation, anesthesia time were obviously more quick compared to spinal anesthesia. Operation time was related to ureteroscope size rather than anesthesia method [5]. Post-operative time out of bed for local anesthesia in our clinical practice was reduced and implication rate was lower compared to lumber anesthesia. Because the urethral mucosa topical anesthesia does not need the help of anesthesiologists, and it is simple operating, therefore, the surgeon can finish it independently, and the operating staffs can also be reduced. In comparison with lumber anesthesia method, surgery under local anesthesia is featured by accelerated surgical room turnaround and lower complications rate. Moreover, patients in TIUA group were discharged from hospital more quickly. All these experiences were the keys to a less suffering, safe, economical ureteroscopic lithotripsy for patients. Thus, it also suggested that ureteral stones therapy can shift from inpatient to outpatient surgery. Both local anesthesia and spinal anesthesia can effectively reduce patients intraoperative pain with a high surgical success rate and no serious complications. As the concept of rapid recovery has matured in the field of urology, we believe that successful local anesthesia could allow ureteroscopy in such patients to be performed in the outpatient operating room, and we are conducting this prospective research work.

Post-operative complications of ureteroscopy include fever, hematuria, urinary infection, mucosal damage, stone migration, ureteral perforation, traumatic avulsion, and urosepsis [20]. Although no severe surgical complications such as perforated ureter and ureteral avulsion of the ureteral mucosa occurred in groups, mild haematuria seemed to be common. Noticeably, in this study, intraoperative RBC and HGB were lost in two groups, but there was no statistical difference between them. Post-operative nausea or vomiting (PONV), headache or dizziness and backache are solely seen in local anesthesia. Female and previous PONV had association with a higher risk of PONV [21]. The headache and dizziness were related to excessive loss of cerebrospinal fluid (CSF). Puncture of the SA has the potential of excessive leakage of CSF, leading to traction on the intracranial

structures in the upright position and venodilatation [22]. Backache was mainly caused by puncture and stent placement. No severe adverse events were observed with the use of atropine, pethidine, and phloroglucinol. Several patients had post-operative back pain, which was considered to be due to the lithotomy position, as described in Table 1 of the article. Our study indicated that local anesthesia had a lower complication rate. This may be the superficial blood vessels in the urethral mucosa, so the absorption of anesthetics is slow.

Pei Lu et al. reported the success and complications of early semirigid URS, and they found a post-operative rise in WBC [23]. Yue Wu et al. provided safe paravertebral block anesthesia for patients undergoing URSL, and they found a serum creatinine increase after surgery [24]. In our study, WBC and CREA got decreased after surgery in some patients who had obstructed their urinary system while others got increased. As a result, the overall WBC was higher than preoperation in two groups. The overall CREA in TIUA group was increased while it was decreased in SA group. The results are mainly caused by the operation involved in urinary system and stress reaction. In our experience, we preventively use antibiotic to lower the risk associated with septicopyemia.

The burden of stones coupled with the advent of new technologies has largely contributed to the higher global medical costs of treating urolithiasis. Many patients require retreatment after surgery to remove urinary stones. The cost of URS remains low and is particularly important in developing countries. Each treatment modality has unique associated costs. In our TIUA group, the treatment cost was significantly more cheaper than SA group. Furthermore, the SA group anesthesia costs was approximately expensive than the local anesthesia. The application of local anesthesia for lower and middle ureteral stones has significant advantage in terms of economic burden.

Although only 22 patients were enrolled, this study is to our knowledge the first to retrospectively evaluated the efficiency and complications associated with the 4.5/6.5 Fr ureteral lithotripsy procedure under the TIUA. In this study, we increased preoperative medication to decrease the possibility of intraoperative alterations to the anesthesia method. Thus the results may be considered effective.

There exist some inadequacies in our study. First, the study was a retrospective design and the number of patients was limited. Second, our study is more suitable for stones in the lower ureter. While the stone is located in the upper ureter, there is a risk of the stone drifting into the renal pelvis during lithotripsy, our method is not able to meet the accident. Thirdly, the advantages and disadvantages of each surgical approach were explained to each patient preoperatively. Because female urethra is short and straight compared to the male, they were more durable. And male patients prefer SA. It contributed to the fact that our study had a smaller sample of men. Further studies on a larger sample of men need to be studied.

Conclusion

Our study showed that both TIUA and SA are able to successfully implement the treatment of ureteral calculi with high SFR and lower complication. Moreover, local anesthesia showed a comparable result in VAS and operative time. In terms of patient admission, waiting time for surgery, anesthesia time, anesthesia cost, post-operative time out of bed, post-operative complications, and overall cost, local anesthesia was a better choice especially for women.

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Author contributions Conceptualization: LQ, QF. Methodology: ZC. Formal analysis and investigation: YQ. Writing—original draft preparation: YQ. Writing—review and editing: ZC. Funding acquisition: LQ. Resources: YZ. Supervision: XQ, YZ.

Data availability The data that support the findings of this study are available from the corresponding aurhor, Lijun Qu, upon reasonable request.

Declarations

Conflict of interest The authors declare there are no conflicts of interest.

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